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Conference Paper

Advanced vs conventional biofuels: Impacts of the latest reform of the European Union's biofuel policy

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1. Introduction

Biofuel production has experienced strong growth over the last years. While global production increased sevenfold between 2000 and 2012 (IEA 2013), growth slowed to relatively modest annual growth rate of 2% due to structural challenges and market uncertainties in key markets (IEA 2017). One of the key consumers of biofuels is the European Union (EU). After promoting the use of biofuels with the Renewable Energy Directive (RED) which came into force in 2009, the EU recast the directive for the time period 2020-2030 (RED II). This new legislation limits the amount of biofuels and bioliquids produced from cereal and other starch-rich crops, sugars and oil crops counting towards the mandate and promotes the use of non-food crops for biofuel production. This paper quantifies the resulting impacts on global land use and agricultural markets.

The RED mandates that at least 20% of all energy usage in the EU be met from renewable sources by 2020, including that at least 10% of each Member State's energy needs for road transport be met from renewables (European Union 2009). In addition, with debates about the net savings in greenhouse gas emissions, additional requirements were introduced, demanding biofuels accounted for the 10%-quota subject to meet sustainability criteria (ebid.). Further, certain biofuels such as biofuels produced from used cooking oil (UCO) and animal fat are double-counted towards the quota. In 2015, the "Directive to reduce indirect land use change for biofuels and bioliquids" ((EU)2015/1513) introduced a cap on food and feed crop-based biofuels of seven percent.

In the RED II a binding EU target of a share of at least 32% of renewable energy in total energy consumption, and of 14% renewable energies in the transport sector is defined. The new directive sets different regulations for biofuels depending on the feedstock and the risk to cause indirect land use change:

A) The proposal aims for a transition towards advanced biofuels (biofuels that are produced from feedstocks listed in part A of Annex IX of the RED II, e.g. algae, straw) by requiring minimum targets of biofuels and biogas produced from these feedstock of 0.2% in 2022, 1% in 2025 and, increasing up to at least 3.5% by 2030 (ebid.).

B) Part B of Annex IX includes e.g. used cooking oil which is double counted towards the target but with no specific minimum targets. They are limited to 1.7% of the energy content of transport fuels supplied for consumption or use on the market.

C) Biofuels produced from food or feed crops are limited to up to one percent point higher than their share in final energy consumption in road and rail transport in 2019 with a maximum of 7%. Member states are allowed to set a lower limit and they may distinguish between different biofuels taking best available evidence on indirect land-use change into account.

D) Biofuels produced from food or feed crops for which a high share of expansion into high-carbon stock is observed shall not exceed the 2019 consumption level unless they are certified to be low indirect land use change-risk biofuels. These biofuels are reduced to 0 until 2030.

The European Commission is supposed to provide a report on the status of worldwide production expansion of crops referred to in D), and define certification criteria. In summary, there is a strong shift from biofuels produced from food or feed crops (conventional biofuels) towards biofuels produced from "advanced biofuels" and other waste produces.

The impact of the first RED on land use change and food prices has been addressed in several studies (e.g. Laborde and Valin 2012, Calzadilla et al. 2016). In the first proposal to reform the RED (EC 2016), a limitation of the biofuel quota of 7% in total transport fuels suggested. This proposal is analyzed by Calzadilla et al. (2016) showing that price increases of crops due to biofuel policies is significantly reduced compared to the 10% target in the RED. The new RED II is not addressed in the literature yet. The objective of this study is to analyze changes in crop prices, production, trade, and land use under the RED and the RED II compared to a reference scenario with no biofuel policies.

2. The DART-BIO model

The Dynamic Applied Regional Trade (DART) model is a multi-sectoral, multi-regional recursive dynamic Computable General Equilibrium (CGE) model of the world economy (e.g. Springer 1998; Klepper and Peterson 2006a). It has been further developed to capture biofuel policies and land use change (Calzadilla et al. 2016, Delzeit et al. 2018).

The DART model is based on recent data from the Global Trade Analysis Project (GTAP) (Aguiar et al. 2016) covering multiple sector and regions. The economy in each region is modelled as a competitive economy with flexible prices and market clearing conditions. The economic structure of DART is fully specified for each region and covers production, investment and final consumption by consumers and the government.

2.1. Aggregation of DART-BIO

We use an updated version of the DART-BIO model, a global recursive-dynamic general equilibrium model (Calzadilla et al. (2016)). The model is calibrated to data from the GTAP9 database (Aguiar et al. 2016). Following Calzadilla et al. (2016), the model includes bioethanol production from sugar cane/beet, wheat, maize and other grains; and biodiesel production from palm oil, soybean oil, rapeseed oil and other oilseed oils. DART-BIO explicitly accounts for the by-products generated during the production process of different vegetable oils and biofuels. Dried distillers grains with solubles (DDGS) are by-products of the production of bioethanol from grains and oilseed meals/cakes are by-products of different vegetable oil industries. Thus, unlike the standard GTAP database, we differentiate between production activities and commodities, which allows to model joint production in the bioethanol and vegetable oil industry. Calzadilla et al. (2016) and Delzeit et al. (2018b) find that differentiating different vegetable oils and their different shares of co-produced meals has an impact on price changes of crops. In an updated version, biodiesel production from used cooking oil, and bioethanol production from straw is added. These two technologies have been identified to be the most important advanced biofuel technologies in a stakeholder process (Delzeit et al. under review). To incorporate the new sectors, we apply the splitcom software using weights calculated from data sources such as COMTRADE, FAOSTAT and F.O. Licht. Details on the construction of the DART-BIO database are available in Delzeit et al. (in preparation).

Central and South America		**Europe**	
BRA	Brazil	FSU	Rest of former Soviet Union
PAC	Paraguay, Argentina, Uruguay, Chile	CEU	Central European Union with Belgium, France, Luxembourg, Netherlands
LAM	Rest of Latin America	DEU	Germany
		MED	Mediterranean with Cyprus, Greece, Italy, Malta, Portugal, Spain
Middle East and Northern Africa		MEE	Eastern European Union with Austria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Romania, Bulgaria, Croatia
MEA	Middle East and Northern Africa	NWE	North-Western European Union with Denmark, Finland, Ireland, Sweden, United Kingdom
AFR	Sub-Saharan Africa	RNE	Rest of Northern Europe: Switzerland, Norway, Lichtenstein, Iceland
Asia		**Northern America**	
CHN	China, Hong Kong	CAN	Canada
IND	India	USA	United States of America
EAS	Eastern Asia with Japan, South		

	Korea, Taiwan, Singapore		
MAI	Malaysia, Indonesia	**Oceania**	
ROA	Rest of Asia	ANC	Australia, New Zealand, Rest of Oceania
RUS	Russia		

Table 1: Regions in DART-BIO

Agricultural related products (29)		**Energy products (14)**	
Crops		COL	Coal
PDR	Paddy rice	CRU	Oil
WHT	Wheat	GAS	Gas
MZE[1]	*Maize*	*MGAS*	*Motor gasoline*
GRON	Other cereal grains	*MDIE*	*Motor diesel*
PLM	*Oil Palm fruit*	OIL	Petroleum and coal products
RSD	*Rapeseed*	ELY	Electricity
SOY	*Soy bean*	*ETHW**	*Bioethanol from wheat*
OSDN	Other oil seeds	*ETHM**	*Bioethanol from maize*
C_B	Sugar cane and sugar beet	*ETHG**	*Bioethanol from other grains*
AGR	Rest of crops	*ETHS*	*Bioethanol from sugar cane*
		ETHC	*Cellulcc Bioethanol from straw*
Processed agricultural products			
VOLN	Other vegetable oils	Biofuels	
SGR	Sugar	*BETH*	*Bioethanol*
FOD	Rest of food	*BDIE*	*Biodiesel*
*PLMoil**	*Palm oil*		
*RSDoil**	*Rapeseed oil*	**Non-energy products (3)**	
*SOYoil**	*Soy bean oil*	CRPN	Other chemical rubber plastic products
*OSDNoil**	*Oil from other oil seeds*	ETS	Paper, minerals and metals
*SOYmeal**	*Soy bean meal*	OTH	Other goods and services
*OSDNmeal**	*Meal from other oil seeds*		
*PLMmeal**	*Palm meal*	**Forest and forest products (2)**	
*RSDmeal**	*Rapeseed meal*	FRS	Forestry
*DDGSw**	*DDGS from wheat*	FRI	Forest related industry
*DDGSm**	*DDGS from maize*		
*DDGSg**	*DDGS from other cereal grains*		
UCO	*Used cooking oil*		
STRAW	*Starches, straw*		
Meat and dairy products			
OLVS	Outdoor livestock and related animal products (cattle and other grazing animals, raw milk and wool)		
ILVS	Indoor livestock (swine, poultry and other animal products from indoor livestock)		
PCM	Processed animal products		

Table 2: Sectors in DART-BIO Note: New products are in cursive. All goods are produced by an analogous industry, except were indicated by an asterisk (*), which indicates jointly produced goods.

Bioethanol and DDGS are jointly produced by the bioethanol industry (3 types of industries); and oilseeds oil and meal are jointly produced by the vegetable oil industry (4 types of industries).

2.2. The theoretical structure of the DART-BIO model

2.3. Dynamics and calibration

The recursive-dynamic character of the model stems from the fact that it solves for a sequence of static one-period equilibria for future time periods, which are connected through capital accumulation and changes in labour supply. The dynamics of the model are mainly driven by exogenous driving forces. Capital accumulation is driven by the savings rate, the gross rate of return on capital, and thus the endogenous rate of capital accumulation. The capital stock of the next period is altered by the current period's investments and depreciation. The allocation of capital among sectors follows from the intra-period optimisation of the firms. The savings behaviour of regional households is characterised by a constant savings rate over time. For all regions but Russia and Sub-Saharan Africa, a depreciation of 4% is assumed. In the calibration process, depreciation for Russia and Sub-Saharan Africa is increased to 6%.

Labour supply and productivity are determined by changes in labour force and the rate of labour productivity growth. DART assumes constant, but regionally different labour productivity improvement rates, constant but regionally different growth rates of human capital, and growth rates of the labour force. Data changes in work force and population growth are taken from OECD (OECD 2019).
Labour productivity is calibrated to match the Gross Domestic Product of the OECD (OECD 2019).

Further, annual growth rates of land productivity are compared to the FAO/OECD Agricultural Outlook (FAO/OECD 2017).

3. The impact of biofuel policies on global agricultural markets

3.1. Definition of scenarios

The reference scenario carries forward the present situation until 2030 with current developments and trends, including current trade policies, and nutritional habits. It assumes no biofuel policies.

The RED scenario assumes global biofuel policies and the RED according to European Union (2009). We align our assumptions of OECD/FAO agricultural outlook of 2016. The national disaggregation for the EU member states, not available from the OECD, is adapted according to the national action plans documenting the national biofuel targets. We assume that these targets will not change between 2020 and 2030. In addition to Delzeit et al. 2018a, who also analyse the impact of global biofuel quotas, we implement used cooking oil as feedstock for biodiesel production.

The RED II scenario takes into account the new EU legislation stating that not more than 7% of the road transport fuel should come from food- or feed-based biofuel sources. There is no minimum biofuel target for these biofuels. This scenario includes double counting of UCO with the limitation of 1.7% of UCO based biofuel of the energy content of transport fuels supplied for consumption.

In a commission delegated regulation from March 2019, biodiesel from palm oil is classified as "high-iluc risk". In addition to the former scenario, in the REDII iluc scenario we test the impact of this proposal by reducing the share of palm-oil-based biodiesel to 0 by 2030.

We analyse the impact of these policies on agricultural prices and production as well as bilateral trade flows.

3.2. Results

To test the sensitivity of our results we test different assumptions on 1) elasticity of substitutions between feedstock used in the livestock sector, 2) availability of used cooking oil and straw, 3) different assumptions on crops with a high share of expansion into high-carbon stock by source country (taking in the report by European Commission due on February 1 2019 into account). In the result section we will discuss implications for production, trade flows, and prices of agricultural goods and processed food and biofuel products. Further we discuss implications for land use change in different world regions.

4. Conclusions and policy implications

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